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SOME OBSERVATIONS ON SLOPE SOARING IN *PANTALA FLAVESCENS* (ODONATA: LIBELLULIDAE)

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Abstract.—Slope soaring behaviour is described for the dragonfly *Pantala flavescens* (Fabricius). Some of the physical and airflow properties of a soaring site are also described. The ability to slope soar may have a significant impact on the energy budget of foraging *P. flavescens*.

Powered flight is a highly energetic activity for insects. Because dragonflies perform most of their adult activities in the air (Corbet 1962; Needham and Westfall 1955), any behaviour that reduces the energy expenditure of flight would be advantageous. One pattern of behaviour that can result in a large reduction in energy expenditure is soaring. Soaring occurs when animals extract energy from the atmosphere by gliding in ascending air currents or updraughts. Consequently, soaring animals can maintain or gain altitude without beating their wings.

Rising air currents can be produced by several mechanisms. Updraughts that are produced by convection are termed thermals (Pennycuick 1975; Scorer 1978; Welch et al. 1977), while those produced by wind interacting with an obstacle, such as a hill, are termed slope lift (Pennycuick 1975; Welch et al. 1977; OSTIV 1978).

Although the dispersal of many insects is known to be enhanced by thermals (Johnson 1969; Rainey 1976; Scorer 1978), the specialized behaviour patterns necessary for sustained soaring flight have only been reported for a few species. These species include the monarch butterfly, *Danaus plexippus* L. (Gibo and Pallett 1979; Schmidt-Koenig 1979), the mourning cloak butterfly, *Nymphalis antiopa* L. (Gibo 1981), and the dragonfly *Pantala flavescens* (Fabricius) (Hankin 1921). *Nymphalis antiopa* and *P. flavescens* have only been observed to soar in thermals, while migrating *D. plexippus* exhibit behaviour patterns that allow them to soar in slope lift as well as thermals (Gibo and Pallett 1979). This note is a report of slope soaring behaviour in foraging *P. flavescens* and also describes the physical features of a soaring site.

On August 11, 1980 a *P. flavescens* was observed slope soaring in an area of lift in the lee of a beach house in Kill Devil Hills, North Carolina. The house was on pilings and raised approximately 2 m above the ground. Although air flow under the house was possible, it was impeded both by the pilings and by a lattice work of slats that ran around the perimeter of the pilings. As a result, air flow over and around the house would normally have a greater velocity than air flow under the house. This flow pattern was apparently producing a form of slope lift in the lee of the house. The exact mechanism may have been due to turbulence (see Munn 1966), a poorly understood three dimensional effect on airflow in the lee of an object (see Scorer 1978), or the Bernoulli principle (see Sears and Zemansky 1970).

The location, dimensions and shape of the area of lift were determined by releasing small bits of paper at appropriate locations and observing whether they were carried upward. The area of lift was located directly in the lee of the house, and was approximately 12 m long, 3 m wide and 2.5 m deep. It was first detectable at approximately 1.5 m above the ground. Wind velocities within the band of lift, and at appropriate locations near the house were measured with a wind meter. The wind direction was from the north. The wind velocity at 1 m was 15 km/hr on either side of the house (approximately 2 m outside the area of lift) and 15 km/hr 1 m above the roof. Directly below the area of lift, at 1 m, the wind velocity was approximately 10 km/hr. The wind velocity within the area of lift, 2 m from the house and 2 m above the ground, was approximately 5 km/hr. The horizontal component of the wind velocity, in this area, was still north (*i.e.* there was no evidence of a counter current). During the observation period the temperature was 24°C and the sky was overcast with broken altocumulus.

The *P. flavescens* was observed from 10:25 to 10:55 A.M. (E.S.T.), while it soared back and forth in the band of lift, generally paralleling the house. The dragonfly tended to fly at a height of approximately 2 m and remain 2 to 3 m from the house. The *P. flavescens* usually soared in a straight line for a distance of approximately 6 m before beating its wings a few times or turning. The duration of the soaring part of the flight was usually 3 s, but ranged between 2–5 s (based on 10 observations). The longer glides extended the entire length of the band of lift. Whenever the *P. flavescens* arrived at the boundaries of the area of lift it made an abrupt 180° turn and usually beat its wings a few times before resuming soaring flight. When the soaring dragonfly was viewed from the front, it could be seen to rock from side to side, indicating that the lift was turbulent.

Occasionally, the *P. flavescens* would suddenly accelerate by beating its wings, and fly 5–10 m in pursuit of small insects. As these flights were usually upward, it was twice possible to observe prey capture against the sky. The dragonfly also employed powered flight to approach other dragonflies that flew near the area, although no overt aggressive encounters were noted. After 30 minutes of observations the dragonfly was collected. Within 10 minutes a second *P. flavescens* flew into the band of lift and began soaring back and forth in the same manner as the first specimen. However, it only remained in the area of lift for approximately 2 minutes.

These observations show that foraging *P. flavescens* are able to locate and soar in restricted areas of lift. It is important to note that the potential foraging area of a slope soaring dragonfly is larger than the narrow area of lift actually being patrolled. Because air continuously flows through the site, dispersing insects that are upwind of the site may drift towards the dragonfly, extending the effective foraging area.

If the energy metabolism for soaring is similar to the resting metabolism (soaring dragonflies are essentially holding their wings immobile), then slope soaring would substantially reduce the cost of patrolling an area. The relative advantage of slope soaring is indicated by studies of endothermic warm-up in dragonflies. May (1979) found that during warm-up active dragonfly species have maximum metabolic rates, that are approximately 19.5 to 29.5 times higher than their resting metabolism. The expected difference in the two metabolic rates for *P. flavescens* can be calculated from the data presented in May (1979). At 30°C the mean resting metabolic rate, from Table I in May (1979) is 0.0024 W. The mean warm-up metabolic rate, extrapolated from Figure 3 in May (1979) and corrected by the recommended 15%, is approximately 0.0680 W. Consequently, for *P. flavescens,* the metabolic rate during endothermic warm-up is approximately 28 times the resting metabolic rate. If warm-up metabolism approximates flight metabolism, then it is apparent that episodes of slope soaring could be very important in the energy budget and ecology of *P. flavescens*.

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